Chapter 9
Continuous Monitoring

Introduction

The Department of Water Resource's Continuous Monitoring Program supplements DWR's monthly discrete Compliance Monitoring Program by providing real-time hourly and quarter-hourly water quality and environmental data from seven shore-based automated sampling stations located in the Upper San Francisco Estuary (Figure 9-1). These stations provide continuous measurements of seven water quality parameters and four environmental parameters, which are used by operators of the State Water Project and the Central Valley Project to assess the impacts of the project operations and to adjust project operations to comply with mandated water quality standards. The Continuous Monitoring Program has been in operation since 1983. This chapter summarizes the results of continuous water quality monitoring at seven sites for calendar year 2003. The stations were divided into three regions for the purposes of detail in the plots:

Figure 9-1 Station locations

Sacramento River stations:	Hood and Rio Vista
San Joaquin River stations:	Mossdale and Stockton
Tidally influenced stations:	Antioch, Mallard Island, and Martinez

Methods

Continuous data are collected for the water quality and environmental parameters shown in Table 9-1. Each of the seven monitoring stations collects continuous data for water temperature, pH, dissolved oxygen, and surface specific conductance. Beginning in April 2003, chlorophyll fluorescence and turbidity data were added for all seven stations. Additional sensors are installed at the Antioch, Mallard Island, and Martinez stations to monitor bottom specific conductance, one and one-half meters above the channel bottom. These measurements, along with river stage data measured at the Mallard and Martinez stations, are needed to determine compliance with the salinity standard (also known as X2) mandated by the Bay-Delta Plan (SWRCB 1995). Environmental data—such as air temperature, solar radiation, wind speed and direction—are measured at all stations except Mossdale (only air temperature) and Hood (none).

Parameter	*Units*	*Frequency*
Water temperature	*°C*	*Hourly average*
Air temperature	*°C*	*Hourly average*
Dissolved oxygen	*mg/L*	*Hourly average*
pH	*unitless*	*Hourly average*
Chlorophyll fluorescence	*fluorescence units*	*Hourly average*
Surface specific conductance	*µS/cm*	*Hourly average*
Bottom specific conductance	*µS/cm*	*15 minute instantaneous*
River stage	*feet Mean Sea Level (NGVD1929)*	*15 minute instantaneous*
Wind speed	*kph*	*15 minute instantaneous*
Wind direction	*degrees*	*15 minute instantaneous*
Solar radiation	*cal/min/cm²*	*15 minute instantaneous*

Table 9-1 Parameters measured by the Continuous Monitoring Program

Except for bottom specific conductance, all water samples are collected at one meter below the water surface using a float-mounted pump and distributed to the water quality sensors. An Ocean Data Equipment model DACTS-80-26 Data Acquisition, Control and Telemetry System scans the output from the sensors once per second and records the hourly average of these approximately 3,600 readings on the hour. Bottom specific conductance and environmental data, such as solar radiation, wind speed and wind direction data, is recorded at 15-minute intervals.

Complete hourly or quarter-hourly data for air and water temperature, pH, dissolved oxygen, surface and bottom specific conductance, and river stage

are available on the Interagency Ecological Program (IEP) database http://wwwiep.water.ca.gov/dss/all/ unless otherwise noted. Data for all other measured parameters are available by request to the Chief of the Real Time Monitoring and Support Section[1].

Results

The monthly averages of the continuous 15-minute or hourly data collected for air and water temperature, pH, dissolved oxygen, surface and bottom specific conductance, chlorophyll fluorescence and turbidity for calendar year 2003 are shown in Figures 9-2 to 9-10.

Water Temperature

Water temperature was measured in degrees Celsius (°C) using a Schneider Instruments RM25C-031 Temperature Parametric System.

Monthly average water temperatures in the San Francisco Estuary ranged from 10.4 °C in January 2003 at the Mallard Island station on the Sacramento River to 26.6 °C in July 2003 at the Stockton station on the San Joaquin River (Figure 9-2).

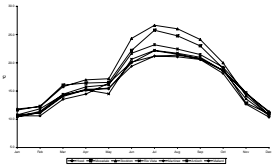


Figure 9-2 Average monthly water temperature at seven stations, 2003

Average monthly water temperatures at the Sacramento River stations were lower in comparison to the San Joaquin River stations, with the greatest divergence occurring in the months of June through September at the San Joaquin River stations of Stockton and Mossdale.

Dissolved Oxygen

Dissolved oxygen was measured using a Schneider Instruments RM25C-033 measuring circuit with a Clark-polarographic probe.

Average monthly dissolved oxygen values for the seven monitoring stations ranged from 1.2 mg/L to 13.3 mg/L (Figure 9-3). The greatest degree of variability was seen at the San Joaquin River stations of Stockton and Mossdale. A monthly average of 1.2 mg/L was calculated for the Stockton station in February 2003, and a value of 13.3 mg/L was calculated for the Mossdale station for August 2003. All other stations showed average monthly averages between 7.8 mg/L and 10.6 mg/L. All compliance monitoring stations, except the Stockton station, recorded values above the standard of 5.0 mg/L set by the Central Valley Water Resources Control Board in the Basin Plan. Monthly average dissolved oxygen values at the Stockton station were highly variable and ranged from 1.2 mg/L to 10.2 mg/L. The Stockton station, located in the Stockton Deep Water Ship Channel, showed a significant DO sag of 1.2 mg/L in February 2003. This pattern of winter sag was first identified in 2000.

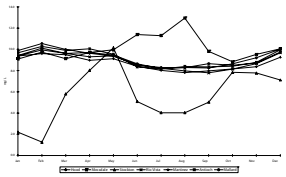


Figure 9-3 Average monthly dissolved oxygen at seven stations, 2003

During the summer and fall of 2003, monthly average dissolved oxygen values at the Mossdale station were exceptionally high. Dissolved oxygen

[1] Chief Real -Time Monitoring and Support Section, Division of Environmental Services, Office of Water Quality, Environmental Water Quality and Estuarine Studies Branch, 901 P Street, Sacramento CA 95814

during the months of June, July, and August 2003 ranged from 11.4 mg/L to 13.0 mg/L. Monthly average dissolved oxygen values in 2002 showed a similar pattern from June to September, ranging from 12.5 mg/L to 13.6 mg/L. The high average summer DO levels seen at the Mossdale station coincided with high chlorophyll fluorescence during the same period. (Figure 9-8)

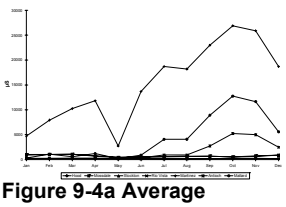


Figure 9-4a Average monthly specific conductance at seven stations, 2003

Figure 9-4b Average monthly specific conductance at four stations, 2003

Specific Conductance

Specific conductance was measured using a Schneider Instruments RM25C-032 system.

Monthly average surface specific conductance for the San Francisco Estuary for the period ranged from 111 µS/cm to 26,882 µS/cm, with the lower values in the Sacramento River at Hood and the higher values at the more tidally influenced Martinez station (Figure 9-4). Data gathered upstream from the Mossdale and Stockton stations on the San Joaquin River show a higher average specific conductance than the data upstream from the Hood and Rio Vista stations on the Sacramento River (Figure 9-4a).

Bottom specific conductance measured at the Antioch, Mallard Island, and Martinez stations exhibited seasonal patterns and ranges similar to the surface specific conductance (Figure 9-5).

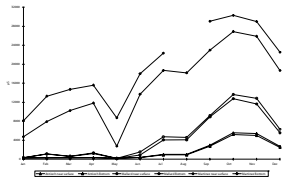


Figure 9-5 Average monthly surface and bottom specific conductance at three tidally influenced stations, 2003

pH

pH was measured using a Schneider Instruments RM25C-035 system.

Monthly average pH levels for the San Francisco Estuary for all stations ranged from 7.1 to 7.9 pH units, with the exception of Mossdale where pH values in June, July, August, and September ranged from 8.2 to 8.8 pH units (Figure 9-6). This increased pH coincided with high chlorophyll fluorescence observed at Mossdale during the same period (Figure 9-9b).

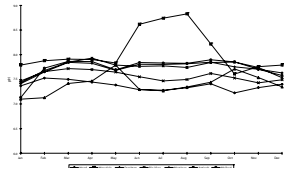


Figure 9-6 Average monthly pH at seven stations, 2003

Air Temperature

Air temperature was measured using a Schneider Instruments RM25C-036 system.

Monthly average air temperatures in the San Francisco Estuary ranged from 9.6 °C in January 2003 at the Rio Vista station on the Sacramento River to 26.6 °C at the Mossdale station on the San Joaquin River (Figure 9-7).

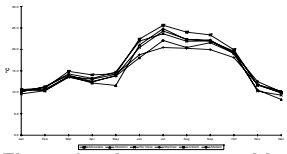


Figure 9-7 Average monthly air temperature at six stations, 2003

Chlorophyll *a* Fluorescence

Chlorophyll *a* fluorescence was measured using a Turner Designs SCUFA Fluorometer set-up with a continuous flow system using chlorophyll *a* filters.

Monthly average chlorophyll *a* fluorescence was recorded at the stations in the San Francisco Estuary from the installation in April 2003 to December 2003 when the instruments were removed for factory upgrade (Figure 9-8a-c). The recorded values ranged from minima of 0.94 fluorescence units (FU) in December 2003 at the Rio Vista station on the Sacramento River to

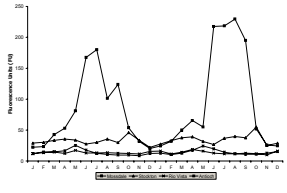


Figure 9-8a-c Average monthly chlorophyll fluorescence at various stations, 2003

maxima of 48.4 FU on August 2003 at the Mossdale station on the San Joaquin River.

Turbidity

Turbidity was measured using a Turner Designs Self-contained Underwater Fluorescence Apparatus (SCUFA®).

Monthly average turbidity was recorded at the stations in the San Francisco Estuary from the installation in April 2003 to December 2003 when the instruments were removed for factory upgrade (Figure 9-9a-c). The recorded values ranged from minima of 3 Nephelometric Turbidity Units (NTU) at the Stockton station on the San Joaquin River in November 2003 to maxima of 46 NTU at the Martinez station near Carquinez Strait in May 2003.

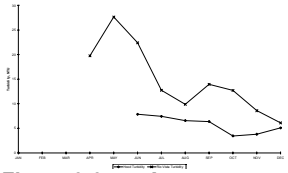


Figure 9-9 a-c Average monthly turbidity at two Sacramento River, San Joaquin River, and tidally influenced stations, 2003

Stockton Ship Channel Dissolved Oxygen

As part of DWR's mandate to monitor water quality in the Delta, a special monitoring study is focused on dissolved oxygen (DO) conditions in the Stockton Ship Channel from Prisoner's Point to the Stockton Turning Basin (See Chapter 7). Continuous data from a monitoring station located in the ship channel (Stockton Station #20) supplements monthly discrete sampling and alerts DWR personnel when DO levels become critical.

The Central Valley Regional Water Quality Control Board has established a baseline objective of 5.0 mg/L for the entire delta (CVRWQCB 1998); however, due to the special concerns in the Stockton Ship Channel to protect fall-run Chinook salmon, a DO objective of 6.0 mg/L has been established for September through November by the State Water Resources Control Board (SWRCB 1995).

For 2003, average monthly DO values at the Stockton station remained above 6.0 mg/L during October and November, but fell below 6.0 mg/L in September (Figure 9-10).

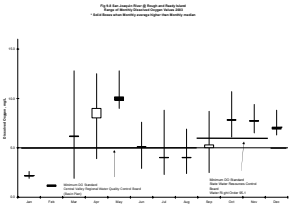


Figure 9-10 Range of monthly dissolved oxygen values at San Joaquin River, Rough and Ready Island 2003

Monthly average DO values in 2003 ranged from 1.2 to 10.2 mg/L. The lowest DO value occurred in February 2003, and the highest value of 10.2 occurred in May 2003. Monthly average DO values dropped well below the state mandated standards from June through September. In 2003, hourly values ranged from 0.1 to 12.8 mg/L. The minimum value of 0.1 mg/L recorded in February 2003 was the lowest value recorded in the last five years. As seen in previous years, the DO levels drop during the summer months of July, August, and September; however, low monthly and hourly DO levels occurred in winter months as well. The pattern of falling DO levels in the winter, first observed in 2000, was again observed in 2003 with a period of near zero DO values from February 9 to February 19.

The box plots (Figure 9-10) show the maximum and minimum range of average hourly DO values for the month, along with monthly medians and averages. Horizontal "whiskers" indicate the range of hourly DO values for each month. Boxes represent monthly medians and means. Open boxes indicate that the monthly median is greater than the monthly mean, with the

top of the box indicating the median, and the bottom of the box indicating the mean. Filled boxes indicate that the monthly mean is greater than the median, with the top of the box indicating the mean and the bottom of the box indicating the median. A horizontal dashed line indicates that the median and the mean are equal.

Summary

Water quality conditions in the upper San Francisco Estuary for the calendar year 2003 were in the expected range of values for water temperature, dissolved oxygen, specific conductance, pH, air temperature, and chlorophyll *a* fluorescence at the Sacramento River stations. The exceptions were found on the San Joaquin River.

The San Joaquin River station at Mossdale showed higher dissolved oxygen, pH, and chlorophyll *a* fluorescence values in the months of June, July, August, and September than any other station in the Estuary. The dissolved oxygen ranged from 9.8 mg/L to 13 mg/L. The pH values ranged from 8.2 to 8.8 pH units. The chlorophyll *a* fluorescence values ranged from 25 FU to 48 FU.

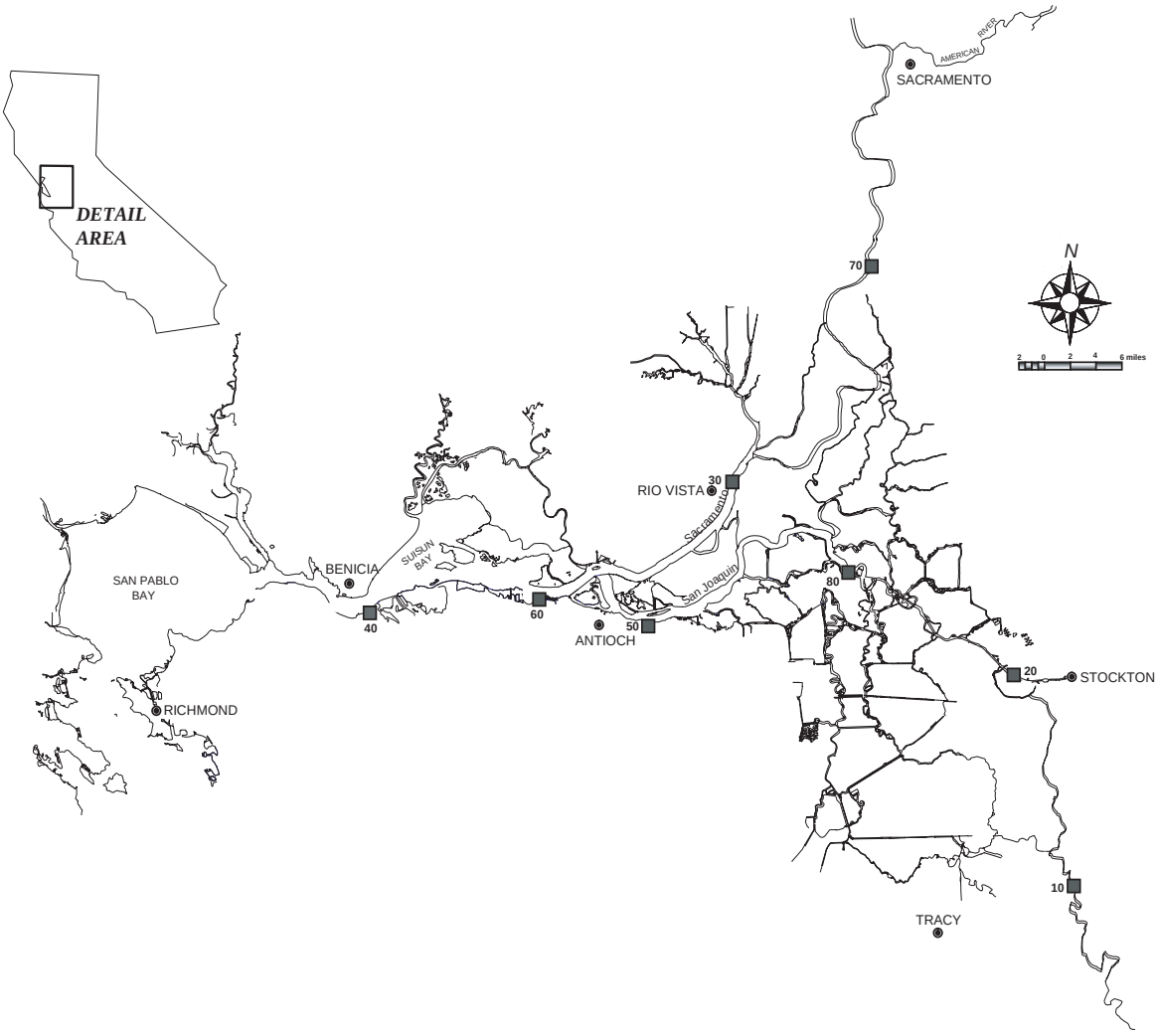
The San Joaquin River station at Stockton showed a dissolved oxygen sag below the 5.0 mg/L objective set by the Central Valley Regional Water Quality Control Board (1998)—unlike any other station in the Estuary for the months of June, July, and August 2003—as well as a second sag below 5.0 mg/L in January and February 2003. The month of September was below the 6.0 mg/L objective set by the State Water Resources Control Board (1995) for the passage of fall-run Chinook salmon through the Stockton Deep Water Channel.

References

[CVRWQCB] Central Valley Regional Water Quality Control Board. 1998. *Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region, the Sacramento River Basin, and San Joaquin River Basin*. Fourth Edition.

[SWRCB] State Water Resources Control Board. 1995. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Estuary*. Adopted May 22, 1995, pursuant to Water Right Order 95-1. Sacramento, CA. 44pp.

Figure 9-1 Station locations



Station #	Location	IEP HEC-DSS database ID
10	San Joaquin River at Mossdale	RSAN087
20	San Joaquin River at Stockton	RSAN058
30	Sacramento River at Rio Vista	RSAC101
40	Sacramento River at Martinez	RSAC054
50	San Joaquin River at Antioch	RSAN007
60	Sacramento River at Mallard Island	RSAC075
70	Sacramento River at Hood	RSAC142
80	San Joaquin River at Prisoners Point (seasonal station)	RSAN037

Figure 9-2 Average monthly water temperature at seven stations, 2003

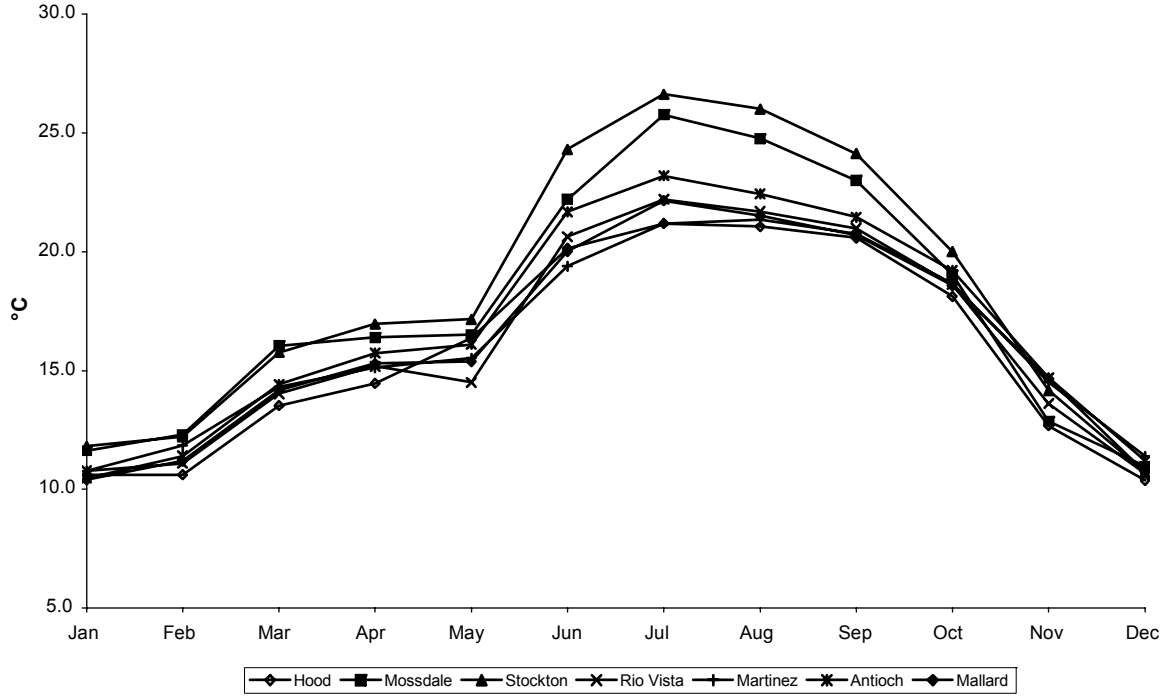


Figure 9-3 Average monthly dissolved oxygen at seven stations, 2003

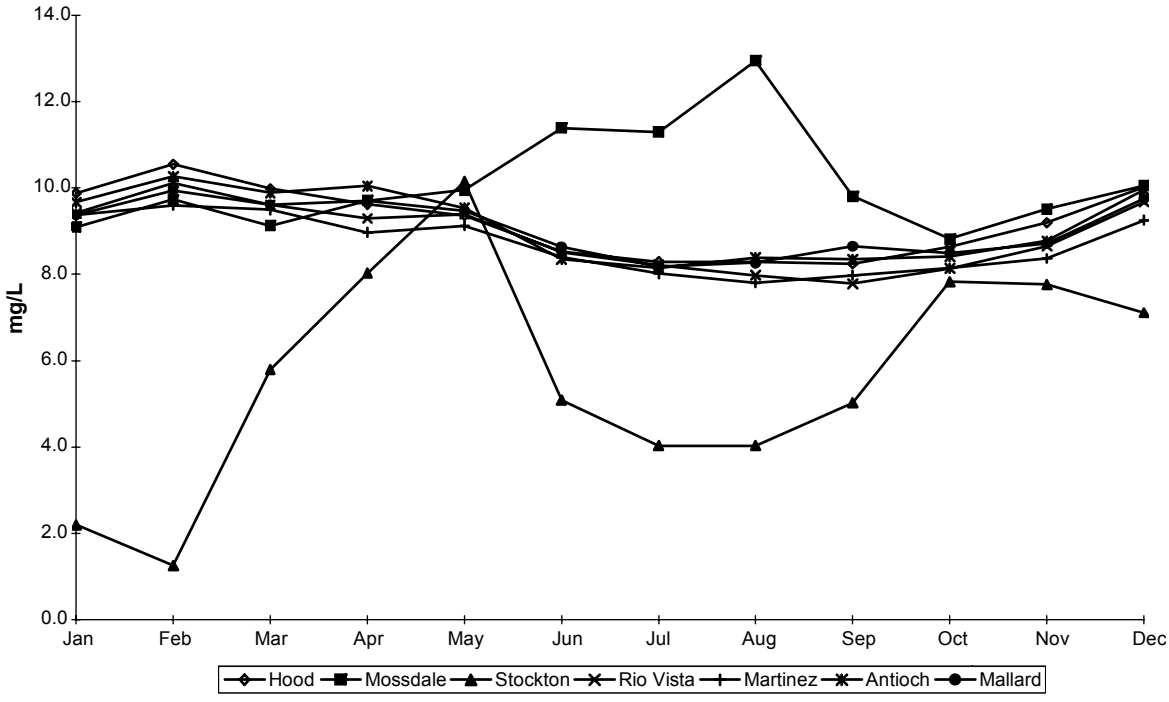


Figure 9-4a Average monthly specific conductance at seven stations, 2003

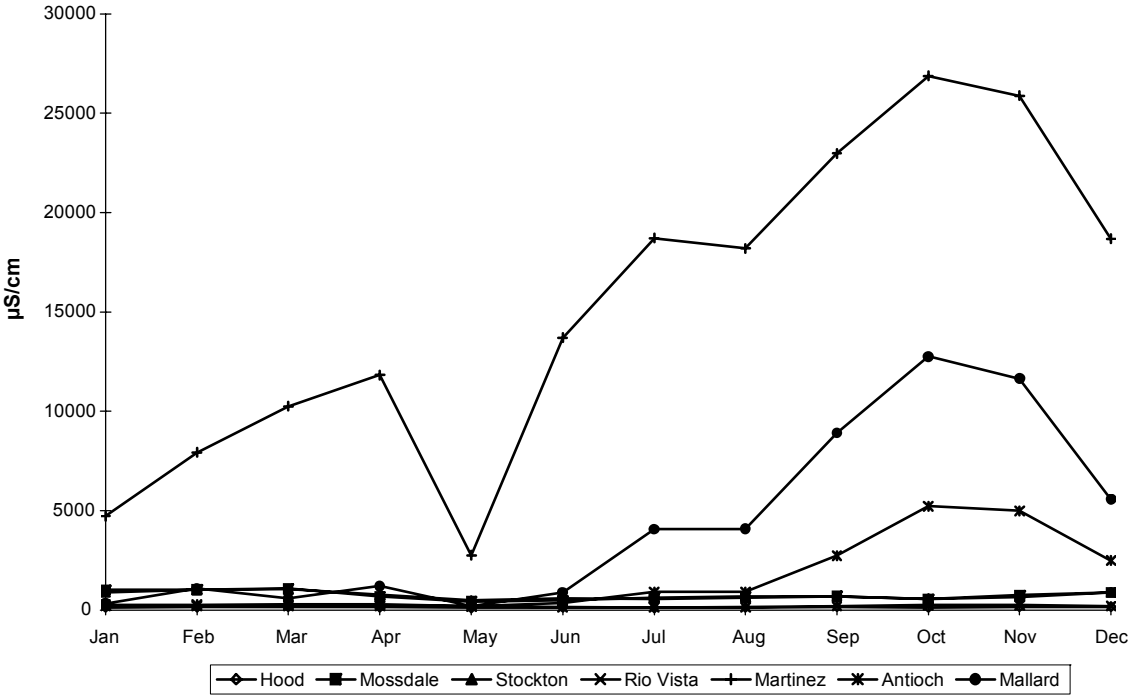


Figure 9-4b Average monthly specific conductance at four stations, 2003

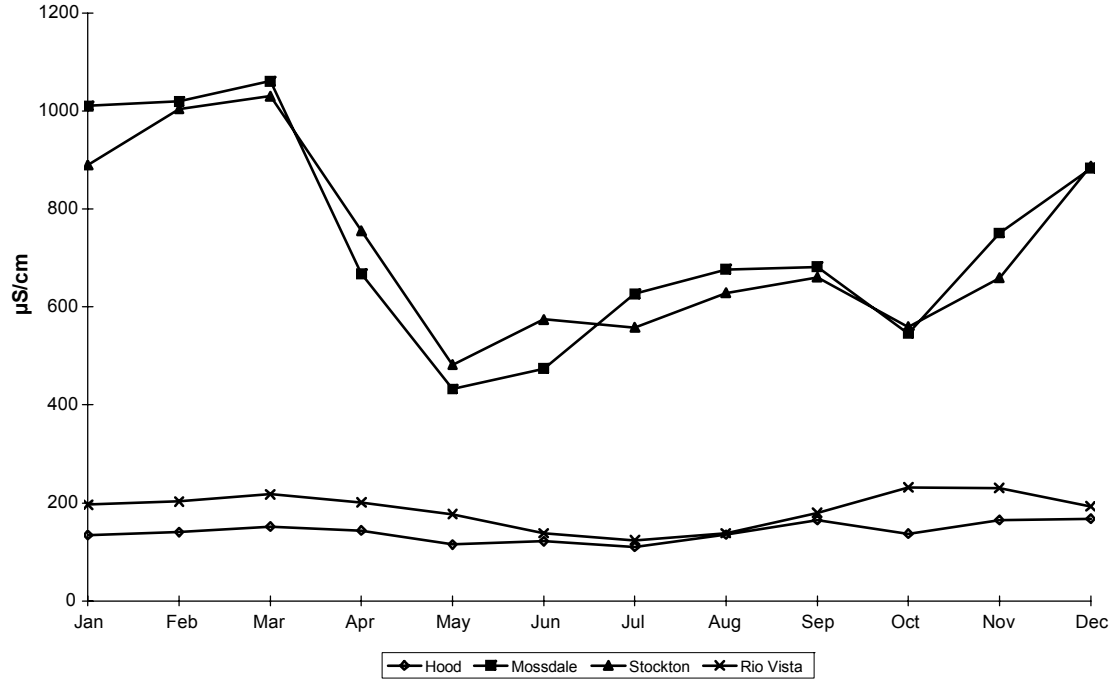


Figure 9-5 Average monthly surface and bottom specific conductance at three tidally influenced stations, 2003

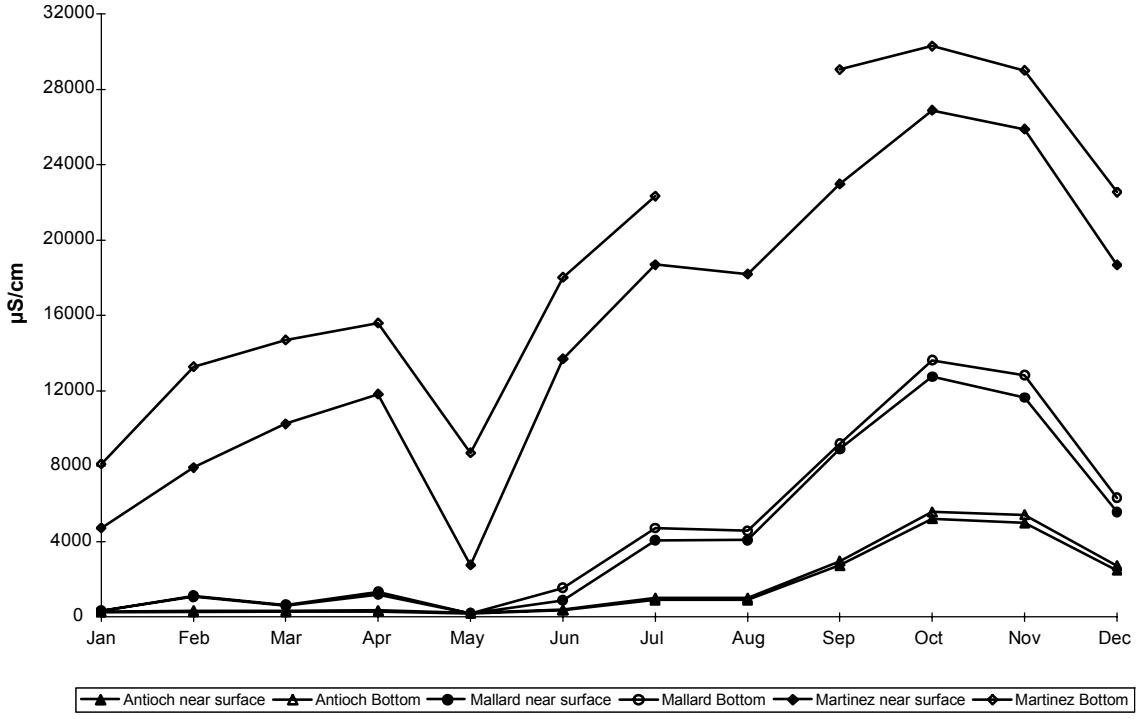


Figure 9-6 Average monthly pH at seven stations, 2003

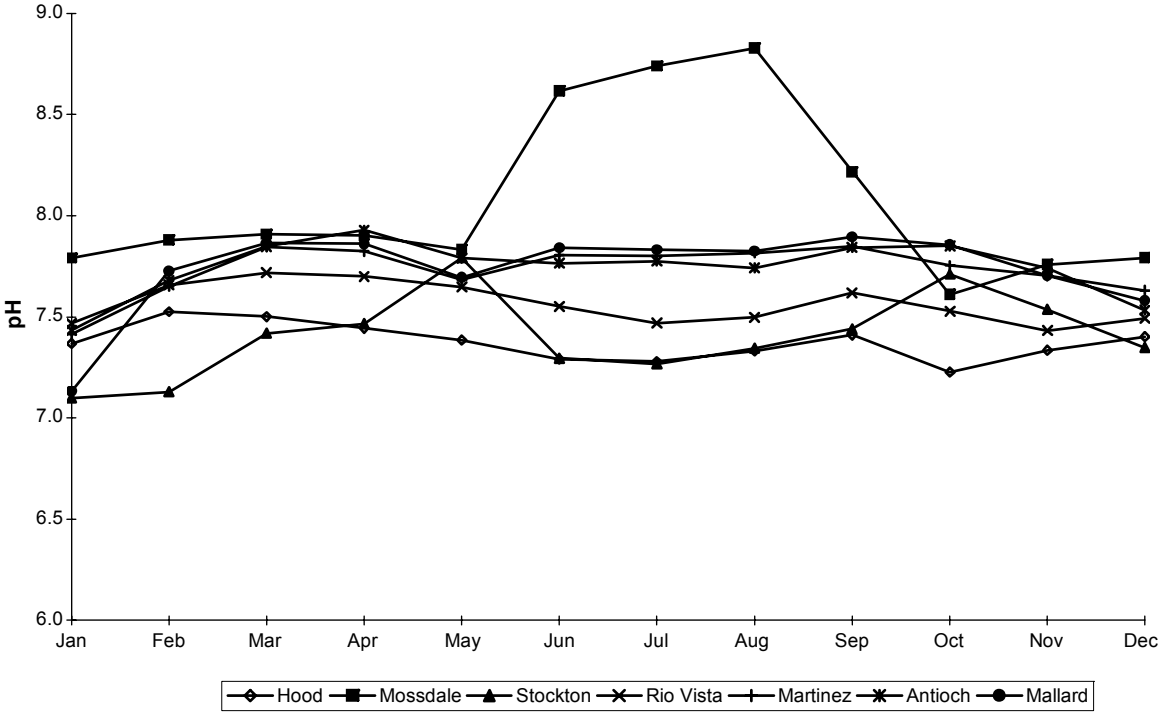


Figure 9-7 Average monthly air temperature at six stations, 2003

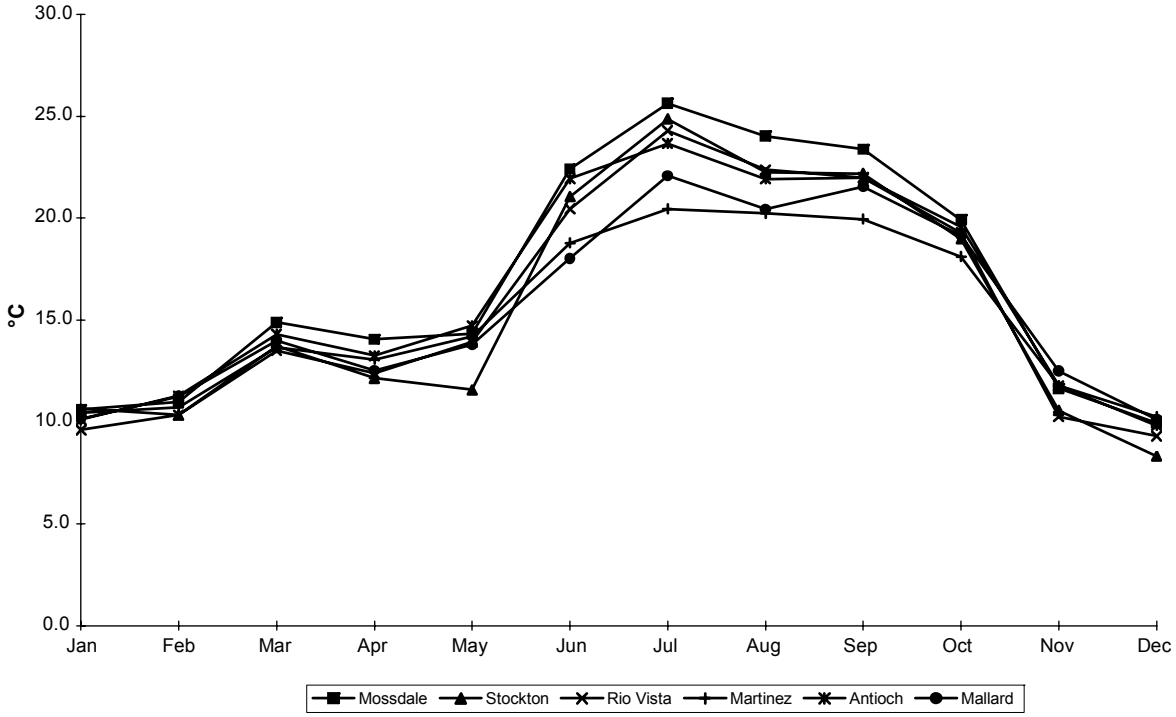


Figure 9-8a Average monthly chlorophyll fluorescence at two Sacramento River stations, 2003

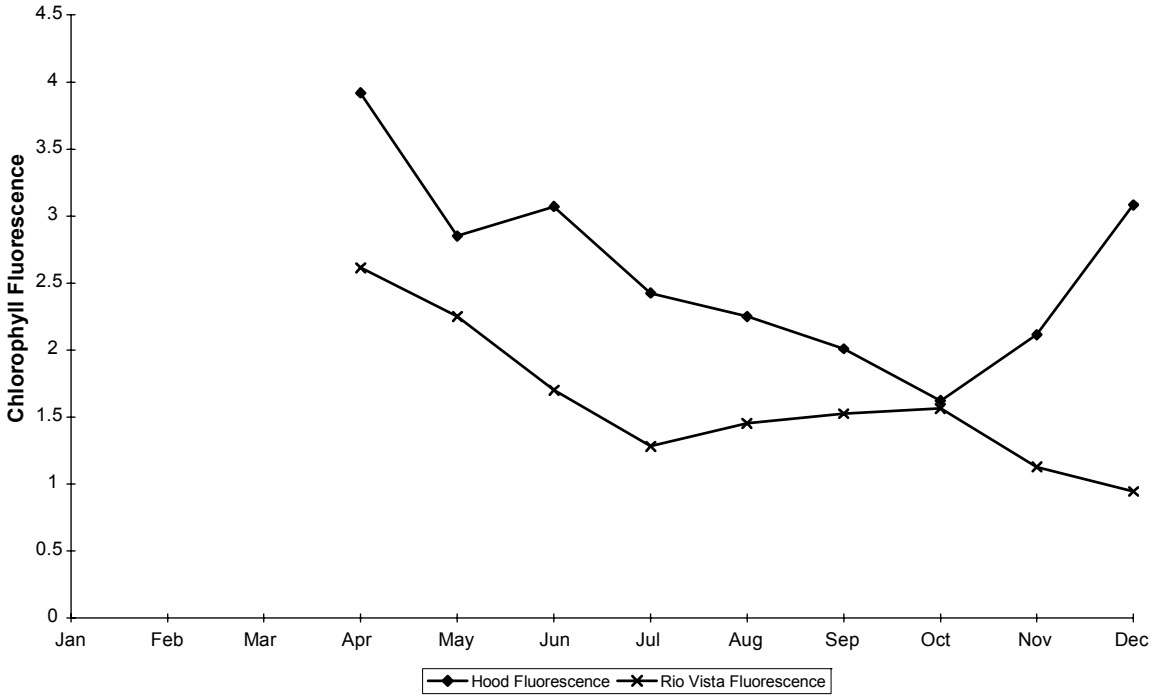


Figure 9-8b Average monthly chlorophyll fluorescence at two San Joaquin River stations, 2003

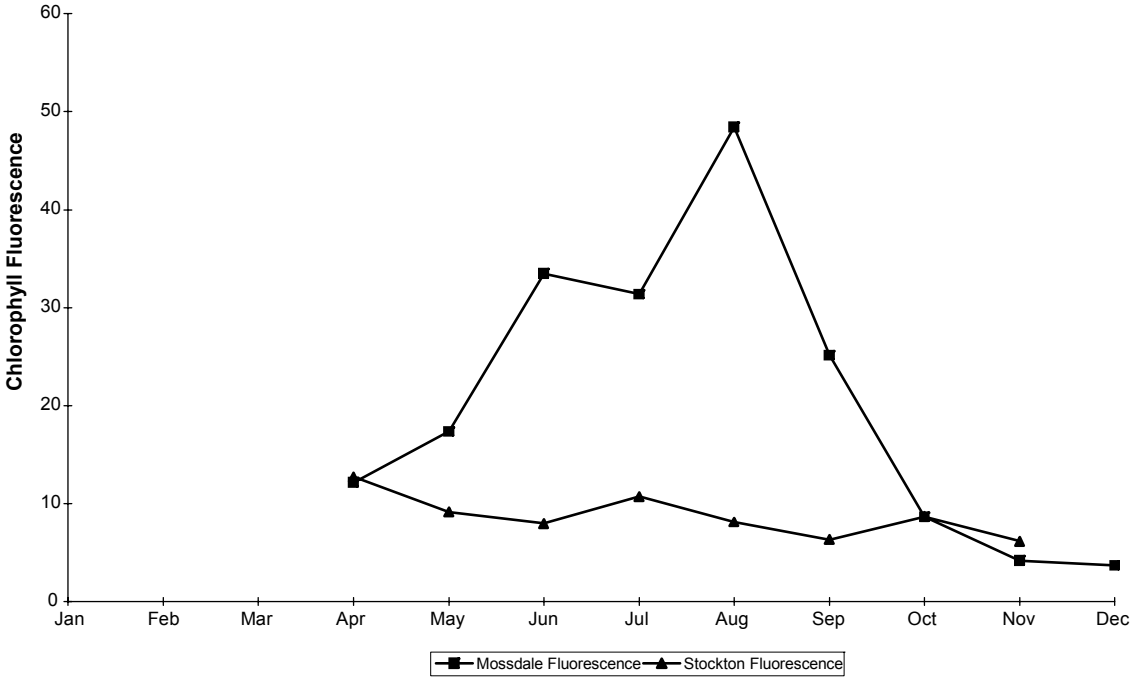


Figure 9-8c Average monthly chlorophyll fluorescence at three tidally influenced stations, 2003

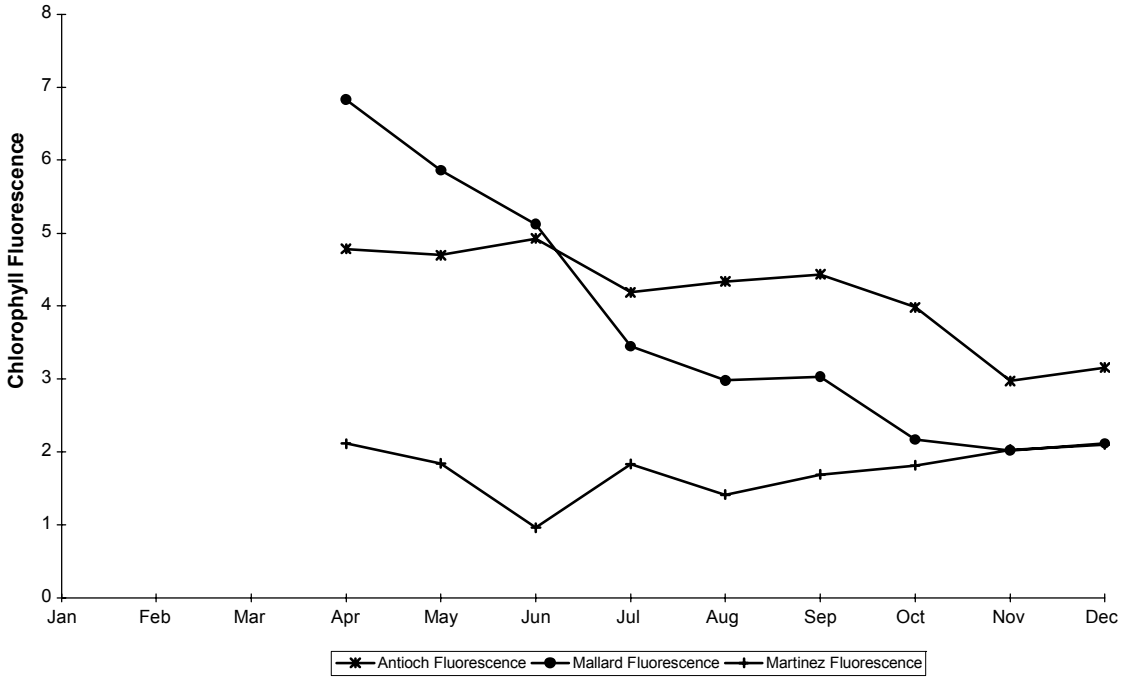


Figure 9-9a Average monthly turbidity at two Sacramento River stations, 2003

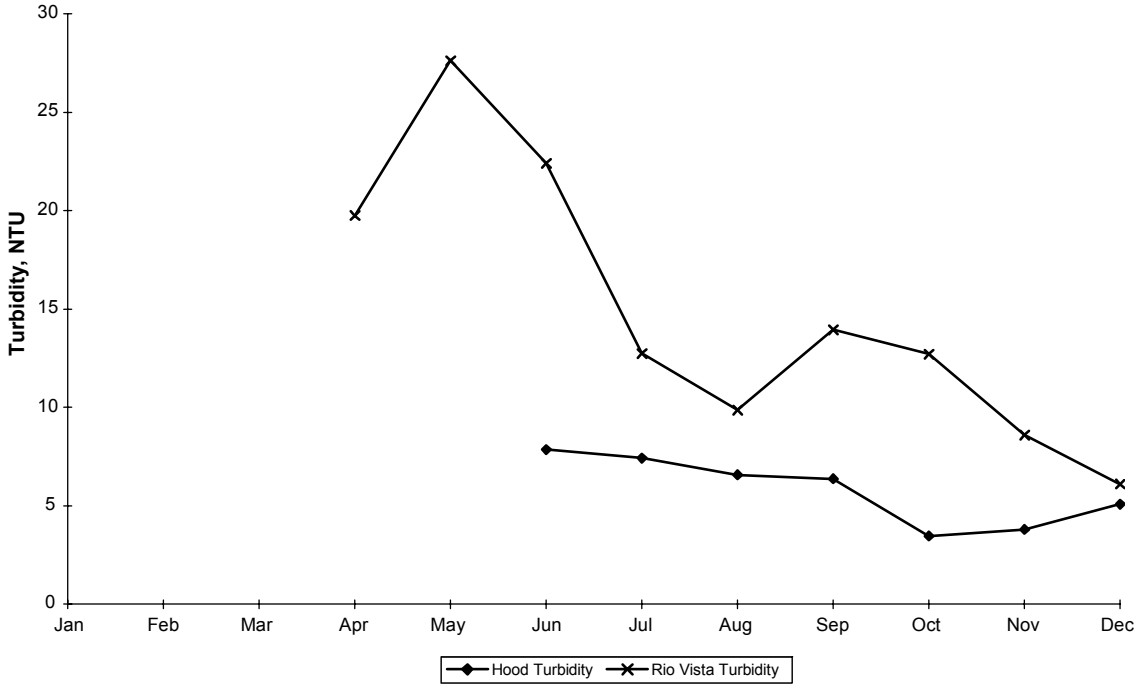


Figure 9-9b Average monthly turbidity at two San Joaquin River stations, 2003

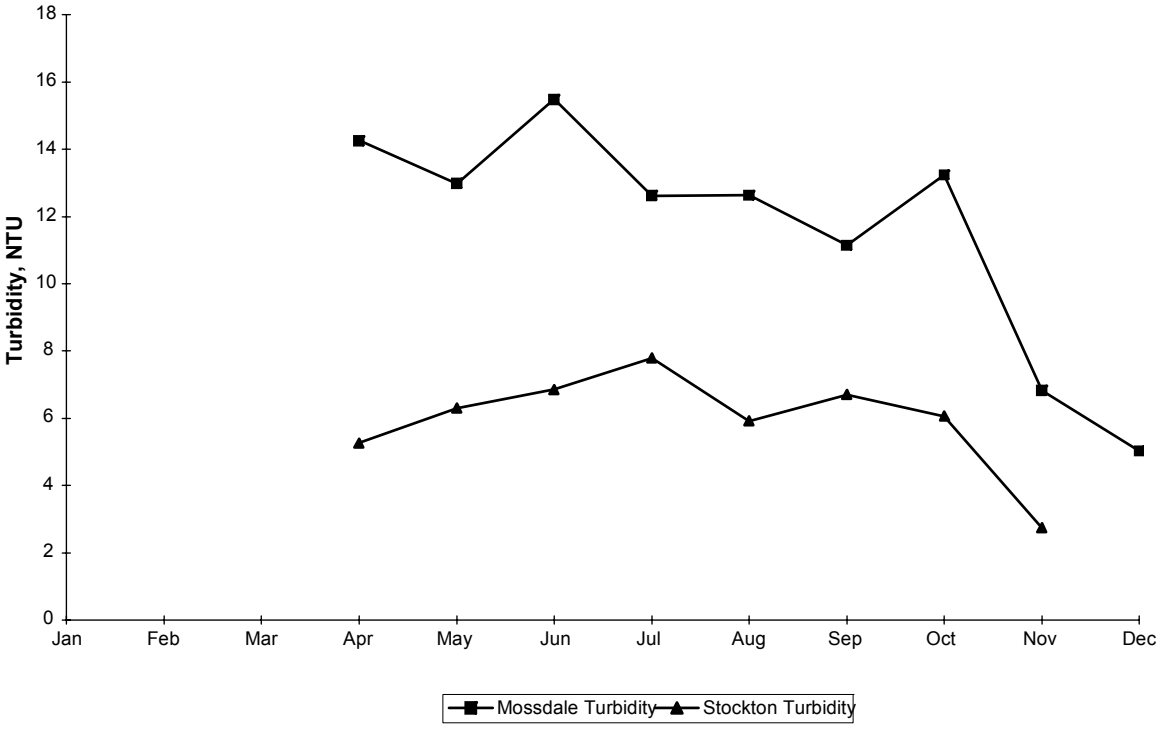


Figure 9-9c Average monthly turbidity at three tidally influenced stations, 2003

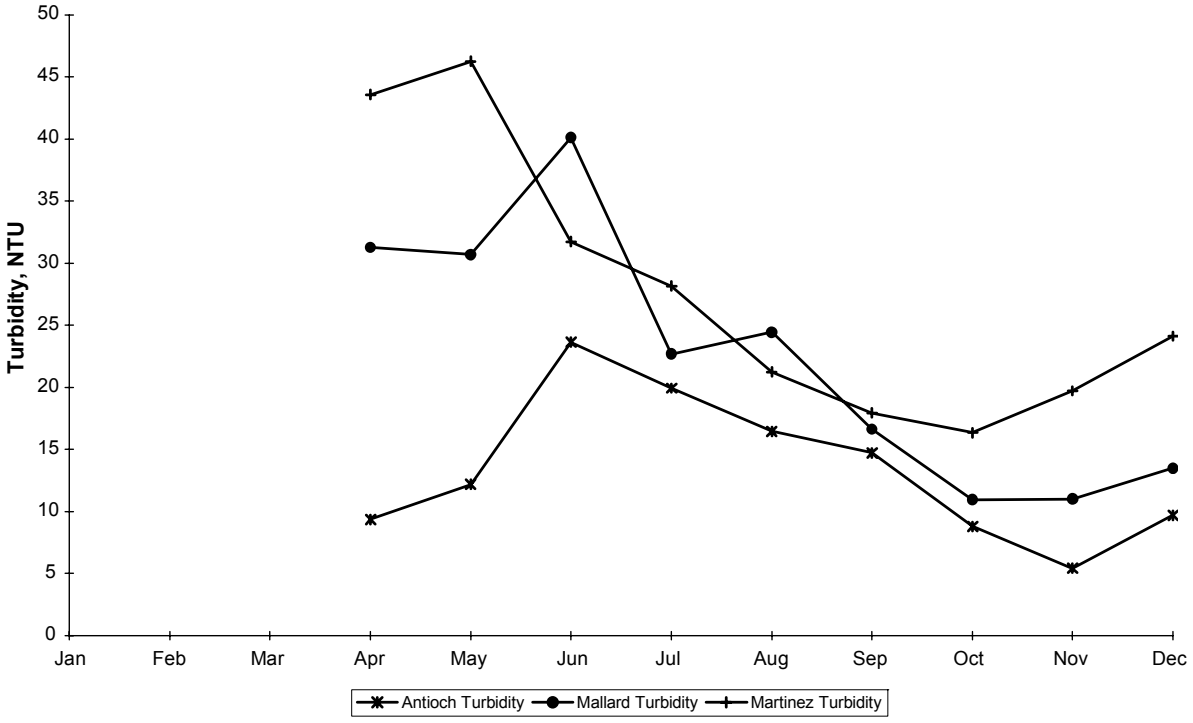


Figure 9-10 Range of monthly dissolved oxygen values at San Joaquin River, Rough and Ready Island, 2003 * Solid boxes when monthly average higher than monthly median

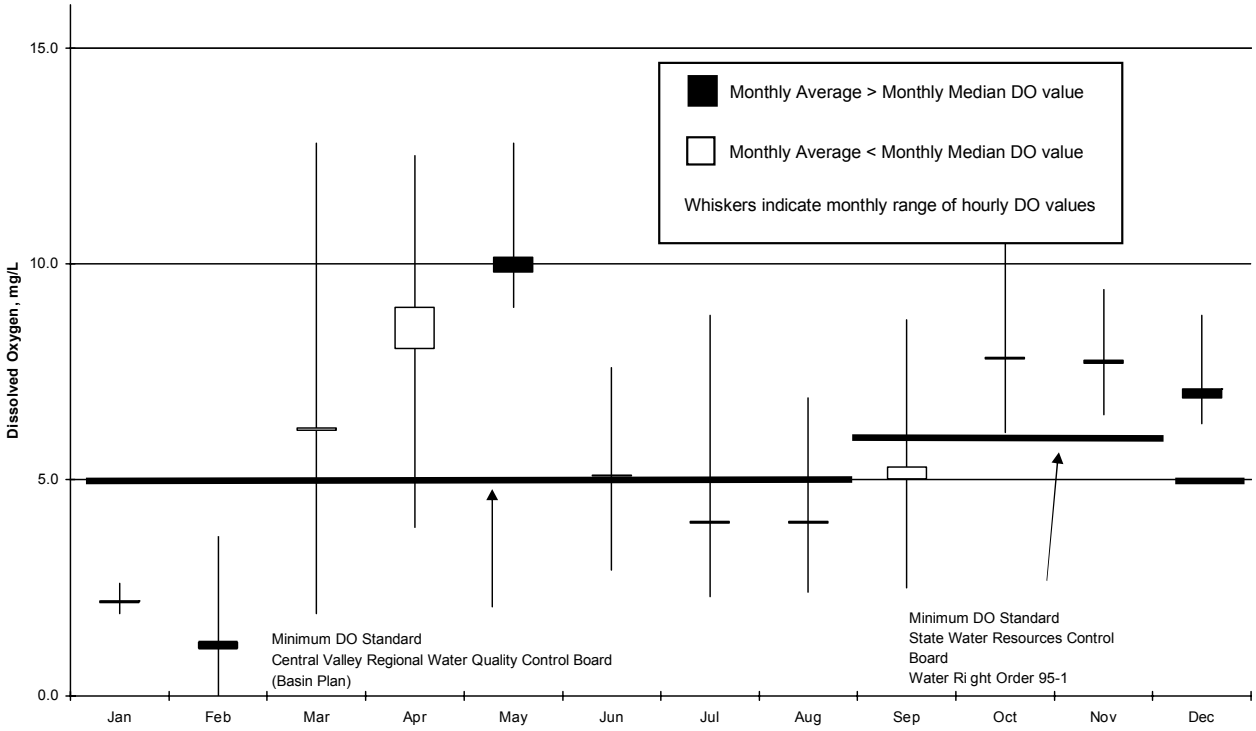


Table 9-1 Parameters measured by the Continuous Monitoring Program

Parameter	Units	Frequency
Water temperature	°C	Hourly average
Air temperature	°C	Hourly average
Dissolved oxygen	mg/L	Hourly average
pH	unitless	Hourly average
Chlorophyll fluorescence	fluorescence units	Hourly average
Surface specific conductance	µS/cm	Hourly average
Bottom specific conductance	µS/cm	15 minute instantaneous
River stage	feet Mean Sea Level (NGVD1929)	15 minute instantaneous
Wind speed	kph	15 minute instantaneous
Wind direction	degrees	15 minute instantaneous
Solar radiation	$cal/min/cm^2$	15 minute instantaneous